Chapter 4

Pathogens

Introduction

Untreated wastewater contains pathogens, such as viruses, bacteria, and animal and human parasites (protozoa and helminths) which may cause various human diseases and illnesses. Oftentimes these pathogens are or become attached to the separated wastewater solids. It is precisely because of the potential presence of pathogens in untreated wastewater that treatment processes are used to clean wastewater prior to discharge to streams. This is also the reason that wastewater residuals must be subjected to additional pathogen reduction treatment prior to land application of the biosolids.

These treatment processes in the U.S. are carefully regulated and monitored to ensure a consistent level of treatment and pathogen destruction. The combination of treatment and appropriate biosolids management at land application sites has proven to be effective in preventing the transmission of pathogens that can cause disease. Incidents of infectious disease, through either direct exposure or food and/or water pathways, have not been documented from land application of biosolids in the U.S. since this combination of regulated practices has been implemented.

The potential exposure to pathogens during proper biosolids storage is no greater than that associated with direct land application. This chapter describes prudent management practices recommended to safely store biosolids in a manner that limits the potential for transmission of disease agents. Information in this chapter relates to all three Critical Control Points, and especially to Critical Control Point 3.

Biosolids Products Characteristics

Biosolids destined for beneficial use in land application must meet pathogen reduction criteria for either Class A or Class B according to Part 503 rules. Only biosolids intended for and that meet Part 503 criteria for safe land application

should be placed in a field stockpile or a constructed storage facility. The two classes of biosolids have different characteristics that influence storage management considerations. Documentation of Class A or B treatment may be achieved either through testing of the final product for specific pathogens or indicator organisms and /or by use of approved treatment processes. Appendix C provides a list of approved Class A and Class B processes.

Class A

Class A biosolids typically are treated by a **"Processes to Further Reduce Pathogens" (PFRP)** such as composting, pasteurization, drying or heat treatment, advanced alkaline treatment, or by testing and meeting the pathogen density limits in Part 503. Class A pathogen reduction reduces the level of pathogenic organisms in the biosolids to a level that does not pose a risk of infectious disease transmission through casual contact or ingestion.

EQ

Class A biosolids which also meet one of Part 503 VAR options 1-8 and meet the metals limits (Part 503 Table 3) are designated as "**Exceptional Quality (EQ)**". These products are exempted from the Part 503 General Requirements, Management Practices and Site Restrictions, and may be generally marketed and distributed.

Class B

Class B biosolids typically are treated using a **"Process to Significantly Reduce Pathogens" (PSRP)** such as aerobic digestion, anaerobic digestion, air drying, and lime stabilization. As an alternative, producers may document compliance by analyzing the material for fecal coliform levels. When Class B requirements are met, the level of pathogenic organisms is *significantly* reduced, but pathogens are still present. In this case, other precautionary measures required by the Part 503 rule , i.e., site and crop harvesting restrictions, are implemented to protection of public health.

In addition to the pathogen reduction requirement, biosolids must also be treated to reduce their attractiveness to vectors such as rodents, flies, mosquitoes, etc. capable of transmitting pathogens. Part 503.33 of the federal rule specifies analytical standards and treatment processes to achieve Vector Attraction Reduction (VAR) requirements. These include volatile solids reduction, elevation of pH, soil incorporation etc. (see Appendix C).

Biosolids Storage Considerations

Pathogens in Stored Class A Biosolids

In general, storage of Class A biosolids present few pathogen concerns due to the level of pathogen reduction achieved by the treatment processes. The potential for exposure to viruses or parasites (helminth ova) in a Class A product is insignificant as a result of treatment and because these organisms

cannot grow outside a suitable host organism. This potential does not increase during storage. Treatment also reduces bacterial pathogens to safe levels. However, bacteria depend on readily available sources of nutrients, adequate water, and favorable environmental conditions, and can grow without a host organism. In specific and very limited situations, the necessary combinations of these factors have been found to occur in stored Class A biosolids. Three examples of these circumstances are:

1. If Class A biosolids compost that is no longer self-heating is blended with green or unstabilized organic materials, such as fresh yard trimmings, fresh hay, or *green* woodchips, the bacterial population can grow rapidly. This is because these fresh materials contain readily available carbon that bacteria need and the compost lacks. If these types of mixtures are managed as self-heating compost piles, i.e., time/temperature conditions adequate to destroy bacterial pathogens are achieved, then the final products will also contain undetectable levels of pathogens as do Class A biosolids. At such low concentrations, disease will not be transmitted even with direct contact with biosolids. If Class A biosolids are mixed with products that contain unavailable carbon sources, such as cellulose and lignin in paper and wood processing residuals, pathogen concentrations will remain undetectable because these nutrients cannot be used by pathogens.

2. If a Class A product is inadequately composted, or its nutrients are not well stabilized bacterial pathogen growth will not occur as long as the material is kept very dry, i.e., total solids content of 80 percent or greater. However, if such dry materials take on moisture during storage, and nutrients, pH, temperature, and other environmental conditions are favorable, pathogen and microbial regrowth could occur. Thus, preparers should be aware that if they conduct various types of blending or permit water content to increase in heat-dried Class A products, the potential for temporary increases in bacterial growth exists

   It is important to recognize that growth during storage is usually a temporary condition in which bacterial populations increase in response to the sudden availability of a food source, but decline to previous low levels once it is consumed. The growth and presence of non-pathogenic microorganisms in biosolids act to counterbalance the stimulating effect of nutrients on bacterial growth through the natural competition for nutrients.

   If pathogen regrowth occurs, the material should be held in storage until populations decline to acceptable levels or it should be re-treated to meet standard pathogen limits. The potential for pathogen growth should be considered in establishing appropriate storage conditions and in blending or augmenting Class A biosolids with other organic materials (see Chapter 7, “Other Organic By-Products”).

3. If the pH of Class A alkaline stabilized material drops significantly during extended storage and the color, consistency, or odor of the product has deteriorated, then re-testing for pathogens may be advisable. Significant

decreases in pH have, on occasion, been associated with increases in the level of fecal coliform above the 1000 MPN per gram regulatory limit.

Pathogens in Stored Class B Biosolids

The probable presence of pathogenic organisms is assumed for biosolids treated to Class B pathogen reduction standards. Likewise, Class B biosolids blended with any other organic materials, e.g., leaves, sawdust, woodchips etc., for whatever reason, is not considered to alter the pathogen status. For this reason, storage practices should provide a level of protection equivalent to Class B site restrictions for use to minimize human, animal, or environmental exposure to disease-causing organisms either through direct contact or via the food chain.

PART 503 PATHOGEN DENSITY LIMITS

Biosolids Pathogen Standards can be satisfied by determining the geometric mean of seven samples of biosolids after treatment for the following:

Pathogen or Indicator	***Standard density limits (dry wt)***
Class A	
• **Salmonella**	**< 3 MPN / 4 g Total Solids or**
• **Fecal Coliforms**	**< 1000 MPN/g and**
• **Enteric Viruses**	**< 1 PFU / 4 g Total Solids and**
• **Viable Helminth Ova**	**< 1 / 4 g Total Solids**
Class B	
Fecal Coliform Density	**<2,000,000 MPN/ g Total Solids (dry wt. basis)**

Accumulated Water

Ponded water that has contacted stored biosolids may contain nutrients and have a moderate enough pH to provide a favorable medium for growth of bacteria, including pathogens. This may occur even when the bulk of the stored product is dry. In addition, according to the preliminary risk assessments for land application of biosolids, the highest risk pathways for viruses, bacteria and parasites involve direct human contact with biosolids or with surface waters that have been contaminated by runoff and sediment, particularly immediately after a rainfall. Therefore, management of stormwater to minimize contact with biosolids and properly dealing with any water that accumulates in contact with stored biosolids is essential.

When is Retesting Required?

Class A and EQ

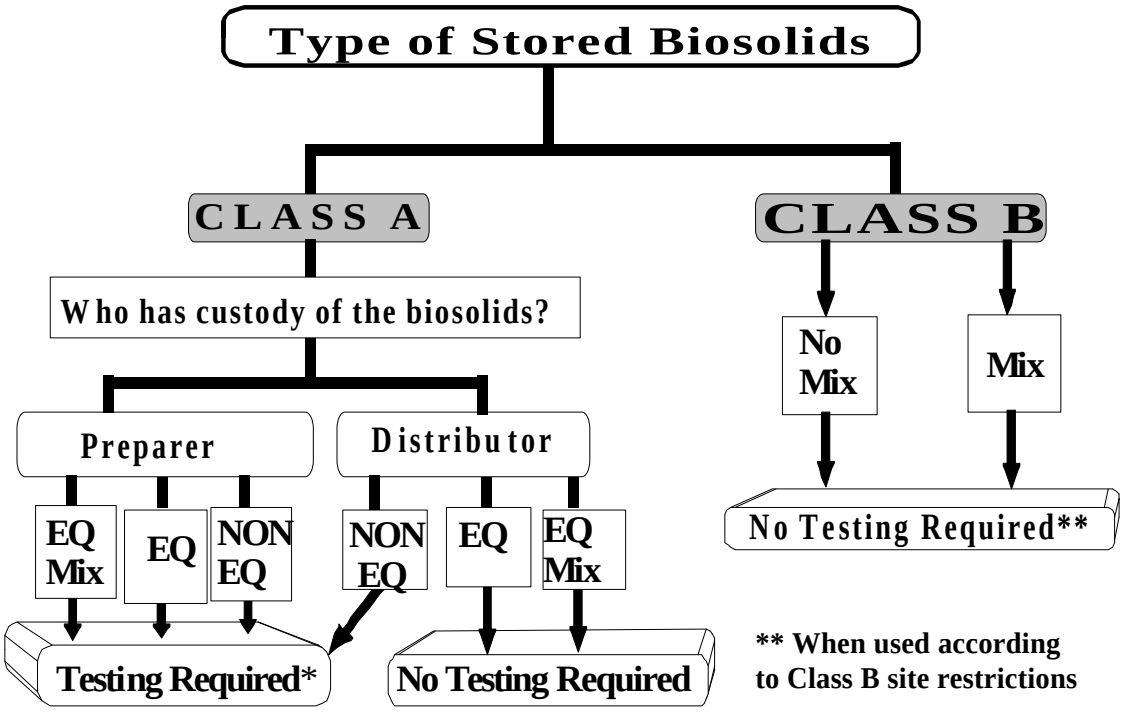
For EQ biosolids the Part 503 requirements to test stored materials prior to use depends on who has control of the stored material. If the material remains in the control of the original preparer (directly or indirectly through a contracted processor or applier), the material must be retested prior to final use. If a preparer gives or sells EQ biosolids to a second party, for instance a landscaper, who then stores the material before land application, testing for pathogens is not required under Part 503.

The two examples above are often referred to as the "quirk" of the EQ concept. In one case, the EQ biosolids is still subject to the Part 503 requirements when something happens to it because it is still *under the control of the preparer*. In the other case, the same EQ biosolids is not subject to the Part 503 requirements when something happens to it because it is *no longer under the control of the preparer*. Loss of control by the preparer is the critical difference conceptually. However, even second party receivers of EQ materials should be aware that pathogen testing is recommended when bulk blending operations of biosolids with materials that contain available nutrients occur.

Class B Material

For Class B biosolids, any mixture of a Class B biosolids and a non-hazardous material is considered as a product derived from biosolids, and hence, by definition, biosolids. Thus, if either a preparer or a land applier blends ground green waste with Class B biosolids, and then plans to till that mixture into the soil the mixture would still need to meet the Part 503 Class B standard and site restrictions (i.e., pollutants, pathogen, and vector attraction reduction requirements). The party who mixes the biosolids with another material is the preparer, as defined in Part 503.

Land appliers who are considering or are already blending biosolids with other materials prior to ultimate disposition of the product need to be aware of Part 503 requirements for biosolids derived products. This means that if the blends with Class B biosolids are stored, when they are removed from storage for land application, they must still use site restrictions.



*** Before custody of the biosolids is transferred to the distributor, OR when something other than EQ biosolids is mixed with NON-EQ biosolids after the preparer has released control of it.**

If anything is mixed with NON-EQ biosolids, the mixture is subject to the land application general requirements and management practices when it is land-applied.

Fig. 4-1. Decision tree diagram showing the interrelationship between biosolids pathogen reduction status (Class A, B, and EQ), current custodian, and mixing with non biosolids material relative to testing and retesting requirements.

Storage Site Management

Three conditions are necessary to produce infectious disease:

- The disease agent must be present in sufficient concentrations to be infectious
- Susceptible individuals must come in contact with the agent in a manner that causes infection
- The agent must be able to overcome the physical and immunological barriers of the individual.

Proper management practices break the chain of transmission either by keeping susceptible individuals or animals from direct contact with stored

materials and/or by preventing the movement of any residual pathogens or parasites in stored materials into the environment in a way that would be harmful. Biosolids regulations are designed to address the first two of three conditions that produce infections disease.

- Biosolids which meet rigorous Class A pathogen reduction standards do not have detectable levels of pathogens and are exempt from site restrictions.
- For Class B biosolids, the risk of transmission of infectious disease agents is reduced to acceptable levels by a combination of treatment to reduce pathogen levels and management practices to minimize the potential for exposure of susceptible individuals to pathogens or parasites.

Management Options to Restrict Potential Movement of Pathogens

- Use of appropriate buffers or filter strips to control runoff from field stockpiles.
- Diverting stormwater runoff away from the stored biosolids.
- Practices such as stormwater containment ponds or collection and irrigation systems for uncovered constructed storage pads or lagoons.
- Enclosure of long term storage of biosolids in facilities with roofed structures to prevent contact with precipitation or runoff where feasible.
- Restriction of public access to field storage sites. Constructed facilities may warrant fencing, but fencing of field storage stockpiles is needed only if storage will occur in areas that are accessible to livestock.
- Any runoff which has been in contact with the biosolids should be kept isolated from any adjacent fruit or vegetable crops that would be harvested, sold in the fresh market, and potentially consumed raw.

Chapter 5 includes detailed discussion of management practices that minimize pathogen transport or exposure risks for a variety of biosolids storage options.

Worker Safety

Worker safety is always a primary consideration and basic hygiene training similar to that of workers at a wastewater treatment plant should be provided to biosolids haulers and storage site staff. The use of good personal hygiene and work habits form the basis of a worker protection program for those handling biosolids. Some specific recommendations include:

1. Wash hands thoroughly with soap and water after contact with biosolids.

2. Avoid touching face, mouth, eyes, nose, genitalia, or open sores and cuts.

3. Wash your hands before you eat, drink, smoke, or use the restroom.

4. Eat in designated areas away from biosolids handling activities.

5. Do not smoke or chew tobacco or gum while working with biosolids.

6. Use gloves to protect against creation of skin abrasions and/or contact between abrasions and biosolids, or surfaces exposed to biosolids, when they occur unexpectedly.

7. Remove excess biosolids from shoes prior to entering vehicle.

8. Keep wounds covered with clean, dry bandages.

9. Flush eyes thoroughly, but gently, if biosolids contact eyes.

10. Change into clean work clothing on a daily basis and, if possible, before going home; reserve work boots for use at storage sites or during biosolids transport.

The Centers for Disease control recommends that immunizations for diphtheria and tetanus be current for the general public, including all wastewater workers. Boosters are recommended every ten years. The tetanus booster should be repeated in the case of a wound that becomes dirty, if the previous booster is more than five years old. Consult a doctor regarding direct exposure through an open wound, eyes, nose, or mouth. It should be noted that a Hepatitis A vaccine has recently been developed and is available to the general public. Consequently, it is recommended that those working with biosolids receive this vaccination as an additional protection.

References

Code of Federal Regulations, 1993. Standards for the Use and Disposal of Sewage Sludge. Title 40, Volume 3, Parts 425 to 699, Federal Register February 19, 1993 (58 FR 9248), US Government Printing Office, Washington, DC [40CFR503.3].

EPA, 1992. Environmental regulations and technology - control of pathogens and vector attraction in sewage sludge, EPA Pub. No. 625/R-92/013, Center for Environmental Research Information, Cincinnati, OH 45268.

EPA, 1992b. Preliminary Risk Assessment for Viruses in Municipal Sewage Sludge Applied to Land. EPA Pub. No. 600/R-92/064, EROC/CSMEE, Columbus, OH.

EPA, 1991a. Preliminary Risk Assessment for Bacteria in Municipal Sewage Sludge Applied to Land. EPA Pub. No. 600/6-91/006, EROC/CSMEE, Columbus, OH.

EPA, 1991b. Preliminary Risk Assessment for Parasites in Municipal Sewage Sludge Applied to Land. EPA Pub. No. 600/6-91/001, EROC/CSMEE, Columbus, OH.

EPA, 1989. Environmental regulations and technology - control of pathogens in municipal wastewater sludge, EPA Pub. No. 625/10-89/006, Center for Environmental Research Information, Cincinnati, OH 45268.

EPA, 1989. Technical support document for pathogen reduction in sewage sludge. Publication no. PB 89-136618. National Technical Information Service, Springfield, Virginia.

EPA, 1985. Health effects of land application of municipal sludge. EPA Pub. No. 600/1-85/015. EPA Health Effects Research Laboratory, Research Triangle Park, North Carolina.

EPA, 1979. Technology Transfer Process Design Manual - Sludge Treatment and Disposal, EPA 625/1-79-011, Center for Environmental Research Information, Cincinnati, Ohio.

Farrell, J.B., V. Bhide, and J.E. Smith, Jr., 1996. Development of EPA's new methods to quantify vector attraction of wastewater sludges. Water Environ. Res. 68, No. 3, 286-294.

Feachem, R.G., D.J. Bradley, H. Garelick, and D.D. Mara. 1983. Sanitation and disease: health aspects of excreta and wastewater management. Wold Bank Studies in Water Supply and Sanitation 3. John Wiley & Sons, New York.

Smith, J. E., Jr., and J. B. Farrell. 1994. Vector Attraction Reduction Issues Associated with the Part 503 Regulations and Supplemental Guidance. in Proceedings of the Water Environment Federation's Conference, "International management of water and wastewater solids for the 21st century: A global perspective", June 19-22, 1994, Washington, D.C., pp 1311-1330.

Strauch, D. 1991. Survival of pathogenic microorganisms and parasites in excreta, manure and sewage sludge. Rev. Sci. Tech. Off. Int. Epizoot. 10(3):813-846.

Yanko, W.A., A.S. Walker, J.L. Jackson, L.L. Libao, and A. L. Gracia. 1995. Enumerating Salmonella in biosolids for compliance with pathogen regulations. Water Environ. Res. 67(3): 364-370.